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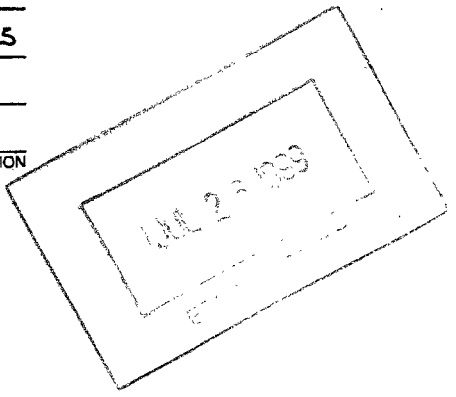

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SUMMARY REPORT FOR THE REVIEW OF 14 RECIPROCATING INTERNAL COMBUSTION ENGINE TESTS

EPA Contract No. 68D20162
Work Assignment No. 3-04

Prepared for

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1. INTRODUCTION

This report was prepared by Pacific Environmental Services, Inc. (PES) for the U.S. Environmental Protection Agency (EPA) under EPA Contract No. 68D20162, Work Assignment No. 3-04. John W. Brown was the EPA Work Assignment Manager for the Emission Measurement Center.

This report summarizes PES' evaluation of 14 emission tests (nine reports) for completeness, appropriate use of EPA test methods, and validity of the reported results. Although some of the test reports contained emissions information on a variety of pollutants, PES based its evaluation of the reports on the data provided by the EMC for the following pollutants:

- formaldehyde — 10 tests
- acetaldehyde — 2 tests
- polynuclear aromatic hydrocarbons — 1 test
- benzene — 1 test

These HAPs were chosen by EMC because they represented the highest emission concentrations found in all of the collected tests.

The reports were evaluated for completeness in supporting documentation, quality of data relative to sampling/analysis, and appropriate use of EPA test methods in generating the test results. In addition, the test reports were reviewed in total for any general situation or condition that would impact the test results, and representative data were audited to verify the accuracy of derived concentrations and emission rates.

The procedures used to review the test reports are described in Section 2 and the review findings are presented in Section 3 and subsequent Tables 3-6.

An appendix is provided at the end of this report which lists the titles of the reports.

2. PROCEDURES USED FOR REVIEW

The following guidelines were used to evaluate each test report.

GENERAL REVIEW GUIDELINES

Documentation

Are the sample and analysis records complete:

- Are records consistent with stated method?
- Are forms appropriately filled-out?
- Are sampling records traceable to the test, personnel, facility, and method?
- Is there any missing information relevant to the test or sampling information?

Process Data

- What is the design capacity of the unit?
- What was the operating condition for each run?

Methodology

- Is the sampling or analysis method appropriate for the parameter being tested? [Yes or no; list the method used.]
- Were there technical modifications which negatively impact the test method or data generated? [State differences and why.]

Quality Control

List the QC points checked and criteria for acceptability related to sample collection and sample analysis for:

- Train component operating temperatures.
- Isokinetic and flows.
- Appropriate sample volume collected.
- Leak Checks.
- Supporting calibration records for sampling equipment.
- Analysis holding times.
- Samples analyzed within demonstrated calibration range.

- QA samples within normal variances for the method.
- Indication of acceptable QC for method blanks, instrument operations, etc.

Audits Performed

Perform a calculation check on 1 run, verifying the stack gas flow rate, sample volume, and derived emission rate.

Overall Assessment

Based on the review, are the test results complete, traceable, and accurately represented?

- Acceptable.
- Acceptable with qualifications (list).
- Insufficient records provided (list).
- Data invalid (state reasons why).

Comments

State any unusual or significant factors that may impact on data quality or its intended use.

3. REVIEW FINDINGS

A general description of each test report is presented in Table 1. A summary of the overall acceptability of the reports (on a pollutant specific basis) is presented in Table 2. Tables 3 through 9 present a more detailed evaluation of the reports on a pollutant-specific basis utilizing the general review guidelines listed in Section 2.

In general, all of the reports have some qualifications associated with the test results due to minor omissions of data (e.g. analytical documentation). However, where these qualifications were minimal, the test results were considered acceptable.

TABLE 1. GENERAL DESCRIPTION OF REPORTS

Facility	Location	Sampling Contractor	Laboratories (parameter)	Test Date	Report Date	General Comments on Test or Conditions
Chevron USA Test ID No. 10	Platform Hope California	Engineering-Science, Inc.	BC Analytical (Formaldehyde)	April 24, 1990	August 29, 1990	Emission report consisting of 3 runs for formaldehyde, on a Cooper-Bessemer natural gas fired IC engine
Gas Research Institute Newberry Springs Station Test ID No. 3.1	California	Accurex	Air Toxics, Ltd (Formaldehyde)	January 29, 1992	October 1992	Emission report of 3 runs for formaldehyde on the exhaust of a TLA-6, 2-cyc., TC, 2000 BHP Dresser-Rand natural gas fired IC engine operated at 80% load and equipped with a precombustion chamber NO_X control kit.
Texaco Davis Lease Test ID No. 7.2	Santa Barbara County, CA	ENSR Consulting and Engineering	ENSR Consulting and Engineering (Formaldehyde)	April 10, 1990	July 1990	Emission report of 3 runs for formaldehyde on a Davis #1, MM605, 60 hp 4-stroke natural gas fired IC engine serving a pumping unit.
UNOCAL/Gato Ridge Test ID No. 7.14	Santa Barbara County, GA	ENSR Consulting and Engineering	ENSR Consulting and Engineering (Formaldehyde)	April 12, 1990	July 1990	Emission report of 3 runs for formaldehyde on a Clark MA-4, 150 hp 2-stroke natural gas fired IC engine serving a compressor.
Gas Research Institute Newberry Springs Station Test ID No. 3.2	California	Accurex	Air Toxics, Ltd. (Formaldehyde)	January 28, 1992	October 1992	Emission report consisting of 3 runs for formaldehyde on the exhaust of a Dresser-Rand TLA-6, 2-cyc., TC, 2000 BHP natural gas fired IC engine operated at 90% load equipped with a precombustion chamber NO_X control kit.

TABLE 1. (Continued)

Facility	Location	Sampling Contractor	Laboratories (parameter)	Test Date	Report Date	General Comments on Test or Conditions
Texaco Exploration and Production, Inc. Test ID No. 21	Ferndale, WA	Emission Technologies, Inc.	Air Toxics, Ltd. (Formaldehyde)	June 27, 1995	June 26, 1995	Emission report on 3 runs for formaldehyde on a 1000 hp, natural gas fired IC engine serving a compressor.
Chevron USA Test ID No. 11.3	Carpinteria, CA	Engineering-Science, Inc.	BC Analytical (Formaldehyde)	April 23, 1990	August 30, 1990	Emission report on 3 runs for formaldehyde on a SHSS natural gas fired IC engine serving a natural gas compressor
Chevron USA Test ID No. 14.5	Carpinteria, CA	Engineering-Science, Inc.	$A_{TM}AA$, Inc. (Formaldehyde)	Unit #1 March 20, 1992 Unit #5 March 31, 1992	May 1, 1992	Emission report on 3 runs for formaldehyde on two Ingasoll-Rand 8-cyl, 410 hp (Unit #1) and 450 hp (Unit #5) turbo charged IC engines with emission controls.
UNOCAL/Gato Ridge Test ID No. 7.14	Santa Barbara County, CA	ENSR Consulting and Engineering	ENSR Air Analysis Laboratory (Benzene)	April 12, 1990	July 1990	Emission report of 3 runs for benzene on a Clark MA-4, 150 hp, 2-stroke natural gas fired IC engine serving a compressor
ARCO Cuyama Test ID No. 7.8	Santa Barbara County, CA	ENSR Consulting and Engineering	ENSR Consulting and Engineering (Acetaldehyde)	April 18, 1990	July 1990	Emission report of 3 runs for acetaldehyde on a Wank 1197, 208 hp, 4-stroke natural gas fired IC engine serving a pumping unit
Ventura Port District Dredge Test ID No. 9	Ventura, CA	BTC Environmental, Inc.	$A_{TM}AA$, Inc. (Formaldehyde)	January 29, 1991	February 25, 1991	Emission report of 3 runs for formaldehyde on a 1600 hp diesel fired engine (Model 248 EMD) producing electric power of 300 amps at 480 volts, serving a barge mounted dredge

TABLE 1. (Concluded)

Facility	Location	Sampling Contractor	Laboratories (parameter)	Test Date	Report Date	General Comments on Test or Conditions
Halliburton Equipment Yard Test ID No. 16	Bakersfield, CA	Entropy	West Coast Analytical Service, Inc. (Formaldehyde)	July 29-31, 1992	October 2, 1992	Emission report of 3 runs for formaldehyde on a Cummins NT335, diesel fuel fired turbo charged IC engine serving a workover rig
L.A. International Airport Test ID No. 6.5	Los Angeles, CA	METCO Environmental	Not Provided	October 25, 1990	October 1990	Emission report on 3 runs for PAHs from a distillate fuel oil fired IC engine
Halliburton Equipment Yard Test ID No. 16	Bakersfield, CA	Entropy	West Coast Analytical Services, Inc. (Acetaldehyde)	July 29-31, 1992	October 2, 1992	Emission report of 3 runs for acetaldehyde on a Cummins NT335, diesel fuel fired turbo charged IC engine serving a workover rig

TABLE 2. REVIEW SUMMARY

Facility Test Report	Formaldehyde	Acetaldehyde	PAH	Benzene
Chevron USA Test ID No. 10	Insufficient documentation to validate test results			
Gas Research Institute Test ID No. 3.1	Insufficient documentation to validate test results			
Texaco Davis Lease Test ID No. 7.2	Acceptable			
UNOCAL Gato Ridge Test ID No. 7.14	Acceptable			Acceptable
Gas Research Institute Test ID No. 3.2	Insufficient documentation to validate test results			
Texaco Exploration and Production, Inc. Test ID No. 21	Unacceptable due to calculation errors in converting concentration to mass rate. Results low by 45%.			
Chevron USA Test ID No. 11.3	Insufficient data to validate results; calculations appear to be incorrect			
Chevron USA Test ID No. 14.5	Unacceptable due to calculation errors. Concentrations overstated by a factor of 1000.			

TABLE 2. (Concluded)

Facility Test Report	Formaldehyde	Acetaldehyde	PAH	Benzene
ARCO Cuyama Test ID No. 7.8		Unacceptable due to calculation errors		
Ventura Port District Dredge Test ID No. 9	Unacceptable due to calculation errors			
Haliburton Equipment Yard Test ID No. 16	Acceptable	Acceptable		
L.A. International Airport Test ID No. 6.5			Insufficient Records	

TABLE 3. EVALUATION OF FORMALDEHYDE DATA

	Chevron USA Test ID No. 10	Gas Research Institute Test ID No. 3.1	Gas Research Institute Test ID No. 3.2	Texaco Davis Lease Test ID No. 7.2
Documentation	Omissions on field data forms	Unacceptable Insufficient documentation	Unacceptable Insufficient documentation	Sufficient
Process Data	Flow and fuel data provided Insufficient data to verify representativeness	Normal steady state at 80% load	Normal steady state at 90% load	No data provided
Methodology	CARB 430	CARB 430	CARB 430	CARB 430
Quality Control	Leak checks not acceptable	No calibration data, blanks and spikes analyzed	No calibration data, blanks and spikes analyzed	Calibration data provided
Audits performed	Run No. 1 concentration calculated incorrectly. Results overstated by 26%	Unable to audit due to lack of documentation	Unable to audit due to lack of documentation	Run No. 1 - Acceptable
Overall Assessment	Data invalid due to calculation errors	Data invalid due to lack of documentation to support results	Data invalid due to lack of documentation to support results	Acceptable w/qualification. No process data
Comments	Reported concentrations in laboratory samples were identical for all three runs	Source was operated under steady state conditions. Concentrations varied from 6 to 66 ppm	Source was operated under steady state conditions. Concentration varied from < 1 to 26 ppm	Results for Runs 1 and 2 were similar. Results for Run 3 much lower - no explanation given

TABLE 3. (Continued)

	UNOCAL Gato Ridge Test ID No. 7.14	Ventura Port District Dredge Test ID No. 9	Chevron USA Test ID No. 11.3	Texaco Exploration and Production, Inc. Test ID No. 21
Documentation	Acceptable	Unacceptable No Field data provided	Unacceptable Omissions on field data forms	Acceptable
Process Data	No data provided	Insufficient Assumed fuel rate from previous test	Acceptable	Acceptable
Methodology	CARB 430	CARB 430 Flow rate based on test from previous year	CARB 430	CARB 430
Quality Control	Calibration data provided	Acceptable Pump calibration provided Sample concentrations corrected for blank	Calibration data provided No reagent blank	Acceptable
Audits performed	Calculations acceptable	Run 2 - unacceptable Sample volumes calculated incorrectly	Run 1 concentration calculated incorrectly	Run 2 - unacceptable, conversion from ppm to lb/hr incorrect
Overall Assessment	Acceptable with qualifications No process data	Unacceptable	Unacceptable	Unacceptable
Comments	Results from all three test runs appear to be consistent and representative			

TABLE 3. (Concluded)

	Chevron USA Test ID No. 14.5	Halliburton Equipment Yard Test ID No. 16		
Documentation	Acceptable	Acceptable		
Process Data	Acceptable	Acceptable		
Methodology	CARB 430	CARB 430		
Quality Control	Acceptable	Acceptable		
Audits performed	Unacceptable Concentrations overstated by 1000 due to calculation error	Acceptable with qualification Calculated sample volumes do not agree with field data because leak check in middle of run was not subtracted out		
Overall Assessment	Unacceptable	Acceptable with qualification Results are slightly understated		
Comments				

TABLE 4. EVALUATION OF ACETALDEHYDE DATA

	ARCO Cuyama Test ID No. 7.8	Haliburton Equipment Yard Test ID No. 16		
Documentation	Unacceptable No process data No documentation of leak checks	Acceptable		
Process Data	Unacceptable Data Not Provided	Acceptable		
Methodology	CARB 430	CARB 430		
Quality control	Unacceptable Meter calibration data does not match meter used in tests	Acceptable		
Audits Performed	Run 1 - Unacceptable Sample volume not calculated correctly	Acceptable with qualifications Sample volumes do not agree with field data because leak check in middle of run was not subtracted out		
Overall Assessment	Unacceptable due to calculation errors	Acceptable with qualifications Results are slightly understated		
Comments				

TABLE 5. EVALUATION OF POLYNUCLEAR AROMATIC HYDROCARBONS (PAH) DATA

	LA International Airport Test ID No. 6.5			
Documentation	Unacceptable No field data No process data			
Process Data	Unacceptable No data provided			
Methodology	CARB 429			
Quality Control	No data provided			
Audits Performed	Unable to audit due to lack of documentation			
Overall Assessment	Unacceptable due to lack of documentation			
Comments				

TABLE 6. EVALUATION OF BENZENE DATA

	UNOCAL/Gato Ridge Test ID No. 7.14			
Documentation	Acceptable			
Process Data	None provided			
Methodology	CARB 401A Acceptable			
Quality Control	Acceptable			
Audits Performed	Run 1 - calculations correct			
Overall Assessment	Acceptable w/qualification only 2 runs			
Comments				

APPENDIX

LIST OF REPORTS PROVIDED FOR REVIEW

1. Test ID No. 10 (Formaldehyde)

   Engineering-Science. Report of: Air Pollution Source Testing for California AB2588 on an Oil Platform Operated By Chevron USA, Inc., Platform Hope, California, April 14, 1990.
   Report Date: August 29, 1990

2. Test ID No. 3.1 (Formaldehyde)

   Gas Research Institute (Acurex Environmental Corporation). Effects of NOx Control on Pollutant Emissions in Natural-Gas-Fueled Stationary Reciprocating Engines, Newberry Springs Station, California, January 29,1992.
   Report Date: October 1992.

3. Test ID No. 7.2 (Formaldehyde)

   ENSR Consulting and Engineering. Pooled Source Emission Test Report: Gas-Fired IC Engines in Santa Barbara County. April 10, 1990.
   Report Date: July 1990

4. Test ID No. 7.14 (Formaldehyde)

   ENSR Consulting and Engineering. Pooled Source Emission Test Report: Gas-Fired IC Engines in Santa Barbara County. April 12, 1990.
   Report Date: July 1990.

5. Test ID No. 3.2 (Formaldehyde)

   Gas Research Substitute (Acurex Environmental Corporation). Effects of NOx Control On Pollutant Emissions in Natural-Gas-Fueled Stationary Reciprocating Engines, Newberry Springs Station, California, January 28, 1992.
   Report Date: October 1992.

6. Test ID No. 21 (Formaldehyde)

   Emission Technologies, Inc. Final Report, Texaco Exploration and Production, Inc., Gas Compressor Emissions Testing, Ferndale, Washington, June 27, 1995.
   Report Date: June 26, 1995.

7. Test ID No. 11.3 (Formaldehyde)

Engineering-Science. Report of: Air Pollution Source Testing for California AB2588 of Engines At the Chevron USA, Inc., Carpinteria Facility, April 23, 1990.
Report Date: August 30, 1990.

8. Test ID No. 14.5 (Formaldehyde)

Engineering-Science. Air Emissions Testing of Internal Combustion Engines for Chevron USA Production Company, Carpinteria, California, March 20 and 31, 1992.
Report Date: May 1, 1992.

9. Test ID No. 7.14 (Benzene)

ENSR Consulting and Engineering. Pooled Source Emission Test Report: Gas-Fired IC Engines in Santa Barbara County, April 12, 1990.
Report Date: July 1990.

10. Test ID No. 7.8 (Acetaldehyde)

ENSR Consulting and Engineering. Pooled Source Emissions Test Report: Gas-Fired IC Engines in Santa Barbara County, April 8, 1990.
Report Date: July 1990.

11. Test ID No. 9 (Formaldehyde)

BTC Environmental, Inc. Ventura Port District Dredge: Air Toxics Emissions Retesting, Ventura Harbor, Ventura, California, January 29, 1991.
Report Date: February 25, 1991.

12. Test ID No. 16 (Formaldehyde)

Western States Petroleum Association (Entropy Environmentalists, Inc.). Source Emissions Testing, Final Test Report, Volume I, Pooled Source Testing of a Rig Diesel-Fired Internal Combustion Engine, July 29-31, 1992.
Report Date: October 2, 1992.

13. Test ID No. 6.5 (PAH)

METCO Environmental. Source Emissions Survey of Los Angeles International Airport Diesel Fired Generating Units, Los Angeles, California, for ERM West, Inc., October 25, 1990.
Report Date: October 1990.

14. Test ID No. 16 (Acetaldehyde)

Western States Petroleum Association (Entropy Environmentalists, Inc.). Source Emissions Testing, Final Test Report, Inc., Volume 1, Pooled Source Testing of a Rig Diesel-Fired Internal Combustion Engine, July 29-31, 1992.
Report Date: October 2, 1992.